Spatial and temporal study of bone marrow lesions in osteoarthritis, and their relationship to denuded bone.

INTRODUCTION

Bone marrow lesions (BMLs), defined as areas of abnormal signal on magnetic resonance (MR) images, have been extensively linked to the osteoarthritis (OA) disease pathway in the knee.

Semiquantitative evaluation has been unable to effectively study the spatial and temporal distribution of BMLs. This study used a novel statistical model to precisely locate the BMLs within the subchondral bone and generate detailed anatomically relevant maps to track their change in size over one year. Furthermore the study compares the distribution of BMLs with the distribution of denuded bone to increase our understanding of their relationship to other joint changes in OA.

METHODS

Individuals (n=88) were selected from the OAI progression groups O.B.1 and I.B.1. Subjects had K-L scores of 2 or 3; medial JSN > lateral JSN, medial osteophytes and ≥1° of varus mal-alignment. OA related BMLs were defined as poorly delineated regions of hyperintensity in the subchondral bone, excluding the region adjacent to ligament attachment sites on Turbo Spin Echo magnetic resonance images (MRIs).

The slice-by-slice, subvoxel delineation of the lesions across the paired images was blinded to time-point but not to subject using EndPoint software (Imorphics, Manchester, UK). Study reproducibility was determined using a Bland Altman test and the measurement error defined as the smallest detectable difference (95% level of agreement).

BML depth with respect to the adjacent bone surface was calculated using an adapted method previously used for articular cartilage thickness measurement (Williams et al, 2010). A statistical bone model was fitted to each image across the cohort, creating a dense set of anatomically corresponded points on the femur, tibia and patella. Parallel, slice-by-slice segmentations were converted into surfaces to calculate BML volume, while the amount of BML adjacent to each corresponded point was measured by taking a normal from each point 15mm into the bone and recording the number of BML voxels traversed. At each point on the surface this provides a measure of BML ‘thickness’ adjacent to that point.

Cartilage thickness was calculated in the same way, using normal’s projecting out from the bone. The association between BML and denudation was also measured semi-quantitatively using visualizations as shown in Figure 2. BMLs were scored as either overlapping or adjacent to denuded bone, or not.

RESULTS

At baseline 75 subjects (93%) had BMLs present in ≥ 1 compartment. The distribution of the lesions (Figure 1) shows a clear pattern as the joint of the femur, or in the patella. Particular significant cartilage change was not seen in the patellofemoral joint of the femur, or in the patella.

DISCUSSION

BMLs are a highly variable feature in subjects with OA, exhibiting a more dynamic development and regression process than previous reports have shown. This study has shown the distribution of lesions follows a very clear trend with the majority found in the patellofemoral joint, medial femoro-tibial joint and medial tibial compartment. The novel method of measurement and display of BMLs in this study demonstrates that there is a striking similarity between the spatial distribution of BMLs and denuded bone in subjects with OA. This co-location infers the lesions have a mechanical origin much like the lesions that occur in healthy patients as a direct result of trauma, e.g. at ligament attachment sites. It is therefore suggested that OA associated BMLs are in fact no different from the BMLs caused by mechanical damage, but occur as a result of localised disruption to the joint mechanics, a common feature of OA.

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